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Measure the Concentration of Alpha Particles and Gamma Rays to Assess the Risk of Cancer in Abo Griq District Soil

Mohsin Kadhim muttaleb[1]*, Saif Mohammed Neamah[1]

[1]Department of physics, college of Science, University of Babylon, Iraq

Abstract : In this study, the level of natural radioactivity and the concentration of radon and bull were measured for 10 models of Abo Griq district –Babylon soil at a depth of 5 cm and 25cm using the Gamma spectrometer system and the solid state detector. The aim of this study is to assess the health risks associated with the activity of natural radiation and the difference in concentration of radon and thoron if any. The results were that the average concentration of radioactivity for ^{40}K, ^{238}U, and ^{232}Th are (68.251±0.888,2.433±0.138, 2.788±0.139)Bq/kg respectively, at a depth of 5cm and (66.224±0.899, 1.918±0.128, 4.225±0.173)Bq/kg respectively, at a depth of 25cm. And the average concentration of radon gas in soil was (612.2 ± 23.007)Bq/m^{-3} in depth 50cm and (150.743 ± 12.78)Bq/m^{-3} in depth 100cm. The results were within the limits recommended by the United Nations Scientific Committee on the Effects of Atomic Radiation.

Keywords : Radon,Thoron, soil, natural radioactivity,Gamma spectrometer.

Introduction

Radioactivity is the process of the spontaneous decay and transformation of unstable atomic nuclei accompanied with the emission of nuclear particles and or electromagnetic radiation (also referred to as nuclear radiation)[1].Large-scale natural radioactivity is observed in the earth, which is found in soil, rocks, plants, water, food, air and building materials[2]. Thus natural radioactivity is important for environmental studies, not just for the effect of radiation, given its great importance in health physics[3].Radionuclides that occur naturally from ground origin originate primarily from radionuclides that have a half-life longer than Earth's age, these primordial radionuclides are ^{238}U, ^{232}Th and their decay products as well as the radioisotopes of ^{40}K. There are two types of radiation sources, radiation of natural and artificial radiation, these rays are divided into two ionizing radiation and non-ionizing radiation[4]. The environmental radiation activity of the natural exposure and associated external exposure due to gamma radiation depends mainly on the local geological and appears at different levels in each region of the world. The normal dose of gamma is a contributor to the average dose received by the world population [5].The important influence of the environment and the lives of objects living is the effect of radioactive radon gas emissions counterparts ^{222}Rn ^{220}Rn, and they are the result of both ^{226}Ra, ^{228}Ra, respectively, and that the increase as the concentration of radium led to severe emission of radon causes cancer [6]. Radon concentration, natural radioactivity in the soil is of great importance to many researchers around the world, leading to national surveys in the last two decades, the measurement of natural radioactivity in the soil is very important to determine the amount of natural background change activity with timely or leak radioactive[7].

2. Theory Concepts

2.1: Specific Activity

The specific activity of a sample is defined as its activity per unit mass (Bq Kg^{-1} or Ci g^{-1}). The specific activity of each sample is calculated using the following formula:

$$A = \frac{N_{net}}{\varepsilon.I\gamma.m.t} \pm \frac{\sqrt{N_{net}}}{\varepsilon.I\gamma.m.t} [Bq\ Kg^{-1}] \text{----------(1)}$$

whereN_{net} area under photo peak, t: counting time sec, Iγ: gamma emission probability, m: sample weight (kg), ε: efficiency of the detector at particular gamma energy [8].

2.2: Outdoor external dose (D_{out}) and Indoor external dose(D_{in}

The outdoor external dose (D_{out}) at 1 m above the ground surface is assessed from the γ-radiation originating from ^{226}Ra, ^{232}Th and ^{40}K supposed to be equally distributed in the ground. The D_{out} was calculated using the following equation (2).

$$D_{out}\ (nGy/h) = 0.462A_U + 0.621A_{Th} + 0.0417A_K \text{----------(2)}$$

The γ-ray dose (D_{in}) imported by ^{226}Ra, ^{232}Th and ^{40}K present in theindoor is calculated using the equation (3)[9].

$$Din\ (nGy/h) = 0.92A_U + 1.1A_{Th} + 0.081A_K \text{----------(3)}$$

2.3: Radium Equivalent Activity (Ra_{eq})

This indices are use to obtain the sum of those activities ^{232}Th, ^{226}Ra and ^{40}K in (Bq/kg) and assess hazards associated with materials that contain ^{232}Th,^{226}Ra and^{40}K in (Bq/kg) by using to radium equivalent activity and is mathematically defined as [10]: $Ra_{eq}(Bq/kg) = A_{Ra} + 1.43A_{Th} + 0.077A_K$ ----------(4)

2.4: Radiation Hazard Indices Calculation

To limit the external gamma-radiation dose from soil sample, an extensively used hazard index, the external hazard index (H_{ex}) and the internal hazard index(H_{in}) was calculated from the equation [11].

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \text{----------(5)}$$

$$H_{in} = \frac{ARa}{185} + \frac{ATh}{259} + \frac{AK}{4810} \leq 1 \text{----------(6)}$$

whereA_{Ra}, $A_{Th}$and $A_K$are the activity concentrations for ^{238}U and ^{232}Th and ^{40}K in Bq/kg.

2.5: The representative level index (I_γ)

The representative level index I_γ of the soil is used to estimate the level of gamma radiation hazard associated with natural gamma emitters in the soil. It was evaluated using the relation given by [12].

$$I_\gamma = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \text{----------(7)}$$

where A_K, A_{Th} and A_U are the activity concentrations (Bq/kg) of potassium, thorium and radium in the soil samples, respectively. The representative level index (I_γ) must be lower than unity in order to keep the radiation hazard insignificant [8].

2.6: Annual Effective Dose Equivalent (AEDE)

To estimate the annual effective dose rates, from absorbed dose the conversion coefficient in air to effective dose(0.7 SvGy-1)the fraction of time spent indoors and outdoors is 0.2 and 0.8 respectively [9].

$$AEDE_{outdor} = \left[D_{out}\left(\frac{nGy}{h}\right) \times 8766\left(\frac{h}{y}\right) \times 0.2 \times 0.7\left(\frac{10^3 mSv}{10^9 nGy}\right)\right] = D_{out} \times 1.226*10^{-3}(mSv/y) \quad \text{----------(8)}$$

$$AEDE_{indoor} = \left[D_{in}\left(\frac{nGy}{h}\right) \times 8766\left(\frac{h}{y}\right) \times 0.8 \times 0.7\left(\frac{10^3 mSv}{10^9 nGy}\right)\right] = D_{in} \times 4.905*10^{-3}(mSv/y) \quad \text{----------(9)}$$

2.7: Excess Lifetime Cancer Risk

The calculated value of excess lifetime cancer risk (ELCR) was calculated using the following equation[9].

$$(ELCR)_{outdoor} = E \times LE \times RF \quad \text{----------(10)}$$

$$(ELCR)_{indoor} = E \times LE \times RF \quad \text{----------(11)}$$

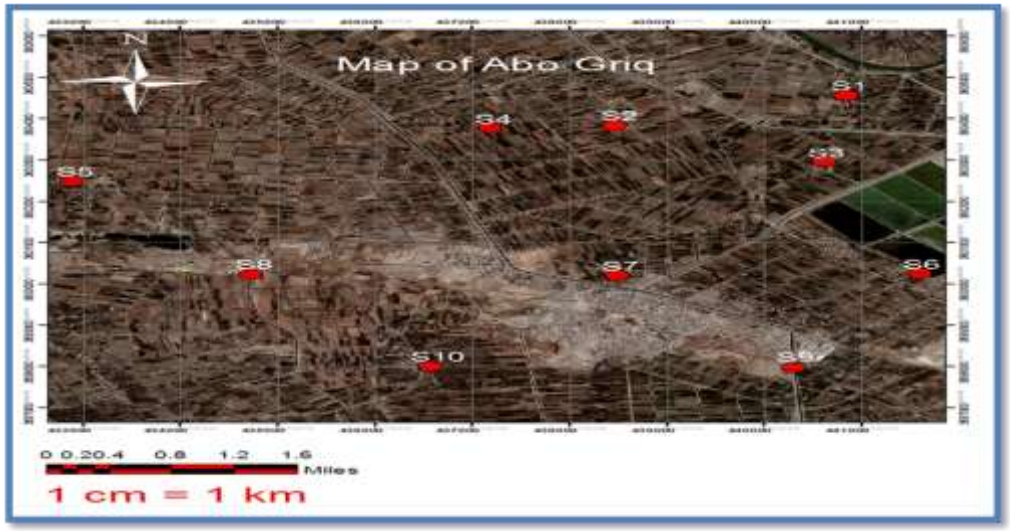
whereE_{out} and E_{in} are the annual outdoor and indoor effective dose, LE is the life expectancy (66 years) and RF (Sv^{-1}) is the risk factor per Siervet, which is 0.05 .

2.8: Geophysical-Chemical Properties of Radon

Thus, radon is present virtually everywhere in the air over the ear. In the natural environment, radon element has three radioactive isotopes; namely: Radon is a natural radioactive gas without odour, colour or taste. It cannot be detected without special equipment. Radon occurs as a product of uranium decay. Uranium is a natural radioactive material found in varying amounts in all rocks, soil, concrete and bricks. It occurs everywhere on earth, especially in rocky and mountainous areas. Radon is an unstable radionuclide that disintegrates through short lived decay products before eventually reaching the end product of stable lead. The short lived decay products of radon are responsible for most of the hazard by inhalation[13]. All people receive exposure from naturally-occurring radioactivity in soil, water, air and food. Radon (^{222}Rn) is emitted from uranium, a naturally-occurring mineral in rocks and soil; ^{222}Rn (3.82 day), ^{220}Rn (55 s), and ^{219}Rn (~4 s). Normally, ^{220}Rn and ^{219}Rn and their progenies are neglected when studying "radon problem" [14].

3. Study Area

Abo Griq district is one of the Hillacity in the province of Babil in central Iraq, about 10 km northwest of the center of Hilla, and passes through the main road linking the province of Karbala. It is famous for its agricultural and industrial activity. It covers an area of 526 km^2 and has a population of 108212 people. Which contains (1058) housing units in accordance with the horizontal construction, In the present study (10) regions were chosen as fair distribution in Abo Griq district –Babylon. The regions were determined using (GIS) as shown in Fig.(1), which was obtained the map sites of the city, drawn by using (GPS) technical.



Figure(1): Map of distribution of sites in Abo Griq district –Babylon

4.Experiments

1. Measurement of Radionuclide Concentrations

Ten soil samples were collected in the study area for different sites Fig. (1). Samples were taken from different depths of 0-5 cm and 5-25 cm. The samples were dried in an oven at 100 ° C for 60 min to remove the moisture from the samples. The samples are mechanically crushed to achieve proper homogeneity and eliminate the impurities by sieve, the samples are stored using a (1L) Marnelle beaker of constant volume and samples were packed in it and left for four weeks to reach radioactive equilibrium before measurement. The samples were analyzed using a NaI(Tl) spectrometer, was used which consists of a scintillation detector NaI(Tl) of (3"×3") crystal dimension, supplied by (Alpha Spectra, Inc.-12I12/3), coupled with a multi-channel analyzer (MCA) (ORTEC –Digi Base) with range of 4096 channel joined with ADC (Analog to Digital Convertor) unit, through interface. Finally, the spectral data was converted directly to the PC of the laboratory introduced using (Maestro-32) software. The system was calibrated in terms of both the energy response and the counting efficiency and the counting time was 18,000s for each sample. The concentrations of the radionuclides of interest were determined using the counting spectrum for each sample. The peaks corresponding to 1.46 MeV (^{40}K), 1.76 MeV (^{214}Bi), and 2.614 MeV (^{208}Tl) were considered when evaluating the ^{40}K, ^{238}Useries, and ^{232}Th-series activities, respectively. The crystal detector resolution was 6% for ^{40}K, 4.4% for the ^{232}Th-series, and 5.5% for the ^{238}U-series. The gamma-ray spectrum activities for each soil sample were analyzed using dedicated software, and references were chosen to achieve sufficient discrimination[15].

2.Measurement of Radon and Thoron Parameters

The soil-gas radon concentration was measure data 10 locations at each location the radon concentration was determined at three different depths (50 and 100 cm). Present measurements of radon concentrations in soil gas were carried out using the RAD7 portable radon detector (Durridge Company Inc. USA). This system contains a solid-state ion-implanted planar silicon detector and a built-in pump with a flow rate of 1 L min-1. Desiccant (CaSO4) tubes is used to absorb the moisture in the soil air, an infra-red HP8224OB alpha-numeric printer placed on the top of the RAD7 and nylon inlet filters (pore size 0.45 μm) that block fine dust particles and radon daughters from entering the RAD7 chamber. The RAD7's internal sample cell is a 0.7 L conducting hemisphere with an average potential of 2200 V relative to the detector that is placed at the center of the hemisphere. The detector operates in external relative humidity ranging from 0% to 99% and internal humidity of 0% to10%. The spectra are in 200 channels and the RAD7 groups them into eight windows of energy ranges. A, B, C, and D are the major windows and E, F, G, and H are the diagnostic windows. Window A covers the energy range from 5.40 to 6.40 MeV, showing the total counts from 6.00 MeV particles from the ^{218}Po decay. Window B covers the region 6.40 MeV to 7.40 MeV, showing the total counts of 6.78 MeV particles from the ^{216}Po. Window C represents total counts of the 7.69 MeV a particles from ^{214}Po, while the window D represents the total counts of the 8.78 MeV a particles from the decay of ^{212}Po. In other words, windows A and B represent ''new'' ^{222}Rn (radon) and ^{220}Rn (thoron), while windows C and D represent ''old'' ^{222}Rn and ^{220}Rn, respectively [16]. RAD7 calculates radon concentrations from the data in window A and B only, and Thoron in window B and D. the built-in pump runs continuously. The soil gas probe used in our study was made of stainless steel with length of 110cm. Detector should be disinfected for 10 minutes using drying unit, The soil probe is placed at the desired depth. It uses a specific operating system for the detector to measure the soil gas. The pump is operated for five minutes per cycle. The radon is removed from the soil and delivered to the measuring room at RAD7. The process continues for four cycles of five minutes per session. After the courses, the results of the test are printed, including radon concentration, humidity, temperature, and standard deviation.

5. Results and Discussions:

5.1.The Activity Concentration

Table (1) shows activity values for radionuclides ^{40}K, ^{238}U,^{232}Th, andradium equivalent(Ra_{eq}) for 10 soil samples of depth (0-5)cm. They have (18.067±0.476; S4 to 172.32±1.47; S9)Bq/kg with an average of 68.251±0.888 Bq/kg, from (0.283±0.053; S1 to 8.354±0.286; S9)Bq/kg with an average of 2.433±0.138 Bq/kg, from (1.343±0.099; S6 to 4.703±0.186; S9)Bq/kg at an average of 2.788±0.139Bq/kg and (5.666;S4 to 28.348;S9)Bq/kg with an average of 11.675±3.417Bq/kg for ^{40}K, ^{238}U, ^{232}Th, and radium equivalent(Ra_{eq}

respectively. Andtable (2) shows activity values for ^{40}K, ^{238}U,^{232}Th, and radium equivalent(Ra_{eq})radionuclides of depth (5-25)cm. They have (31.496±0.628; S7 to 116.72±1.21; S9)Bq/kg with an average of 66.224±0.899Bq/kg, from (0.586±0.076; S3 to 6.869 ±0.259; S9)Bq/kg with an average of 1.918±0.128 Bq/kg, (1.996±0.121; S10 to 7.469±0.234; S7) Bq/kg at an average of 4.225±0.173 Bq/kg and (8.037;S3 to 20.871;S9)Bq/kg with an average of 13.059±3.614Bq/kg for ^{40}K, ^{238}U, ^{232}Th, and radium equivalent(Ra_{eq}) respectively. Results in both tables showed that all measured values of ^{40}K, ^{238}U, ^{232}Th, and radium equivalentRa_{eq} these results are within and below the allowable limit for all soil samples recommended by United Nations Scientific Committee on the Effects of Atomic Radiation [17].

Table (1) Results of natural radioactivity, radium equivalent in soil samples from the surface (0-5) cm

No.	S. C.	Activity Concentration [Bq/kg]			(Ra_{eq})[Bq/kg]
		^{40}K	^{238}U	^{232}Th	
1	S1	69.511±0.934	0.283±0.053	2.010±0.121	8.510
2	S2	65.762±0.908	1.759±0.131	2.069±0.123	9.781
3	S3	52.760±0.813	0.430±0.065	4.497±0.182	10.924
4	S4	18.067±0.476	1.495±0.121	1.944±0.119	5.666
5	S5	74.752±0.968	3.029±0.172	1.907±0.118	11.513
6	S6	90.763±1.067	3.449±0.184	1.343±0.099	12.358
7	S7	56.672±0.843	3.322±0.180	3.492±0.160	12.680
8	S8	24.211±0.551	0.303±0.054	4.108±0.174	8.042
9	S9	172.32±1.470	8.354±0.286	4.703±0.186	28.348
10	S10	57.700±0.851	1.905±0.136	1.805±0.115	8.929
Maximum		172.32±1.470	8.354±0.286	4.703±0.186	28.348
Minimum		18.067±0.476	0.283±0.053	1.343±0.099	5.666
Average±S.D.		68.251±0.888	2.433±0.138	2.788±0.139	11.675±3.417
P. L.		400	32	30	370

Table (2) Results of natural radioactivity, radium equivalent in soil samples from the surface (5-25) cm

No.	S. C.	Activity Concentration [Bq/kg]			(Ra_{eq})[Bq/kg]
		^{40}K	^{238}U	^{232}Th	
1	S1	79.379±0.998	2.365±0.152	5.568±0.202	16.440
2	S2	65.336±0.905	1.006±0.099	2.839±0.144	10.097
3	S3	49.35±0.7870	0.586±0.076	2.553±0.137	8.037
4	S4	61.173±0.876	2.081±0.143	3.382±0.158	11.628
5	S5	70.451±0.940	1.085±0.103	4.512±0.182	12.961
6	S6	81.573±1.011	0.948±0.096	5.803±0.206	15.527
7	S7	31.496±0.628	1.749±0.131	7.469±0.234	14.854
8	S8	47.833±0.774	1.729±0.130	4.622±0.184	12.022
9	S9	116.72±1.210	6.869±0.259	3.507±0.160	20.871
10	S10	58.929±0.860	0.762±0.086	1.996±0.121	8.153
Maximum		116.72±1.210	6.869 ±0.259	7.469±0.234	20.871
Minimum		31.496±0.628	0.586±0.076	1.996±0.121	8.037
Average±S.D.		66.224±0.899	1.918±0.128	4.225±0.173	13.059±3.614
P. L.		400	32	30	370

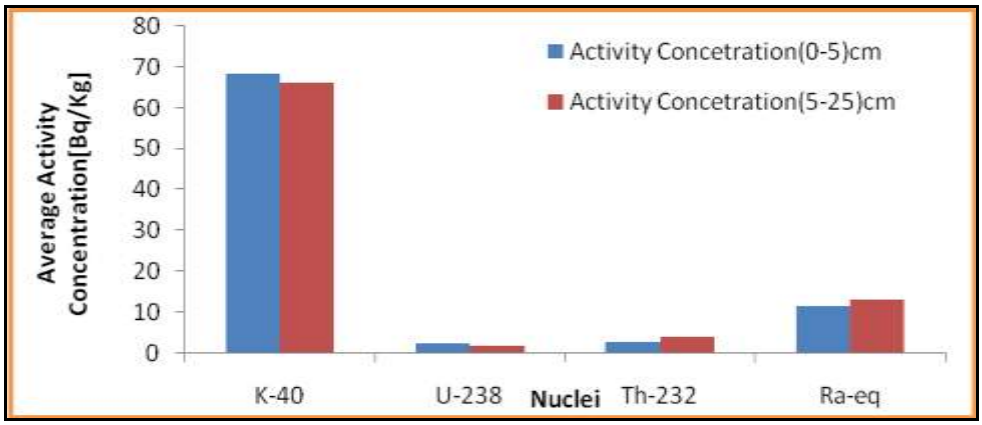


Figure (2):Average natural radioactivity in the soil (0-5) cm and (5-25) cm

In table (3), the following were calculated: external risk indicators (H_{ex}) were calculated. from (0.015;S4 to 0.077;S9) with average 0.031±0.18and Internal hazard index (H_{in}) range from (0.019;S4 to 0.099;S9) with average 0.376±0.61,representative level index (Iγ) range from (0.042;S4 to 0.218;S9) with average 0.851±0.92. As illustrated in table 3, the values of outdoor absorbed dose rate D_{out} vary between (2.651;S4 and 13.966;S9)nGy/h, while the values of indoor absorbed dose rate D_{in} vary between (4.977;S4to26.817;S9) nGy/h. While in table (4), the following were calculated: external risk indicators (H_{ex}) were calculated, from (0.021;S3 to 0.056;S9) with average 0.035±0.19 and internal hazard index (H_{in}) range from (0.023;S3 to 0.075;S9) with average 0.041±0.20,Representative level index (Iγ) range from (0.062;S3 to 0.159;S9) with average 0.095±0.30.As illustrated in table (4), the values of outdoor absorbed dose rate D_{out} vary between (3.914;S3 and 10.218; S9)nGy/h, while the values of indoor absorbed dose rate D_{in}vary between (7.345;S3 and 19.631; S9)nGy/h.We note that the results of the two tables are lower than recommended by the United Nations Scientific Committee [18].

Table (3) Results H_{ex}, H_{in}, I_{γ}, D_{out}, and D_{in} of soil samples taken from the surface (0-5)cm

No.	S. C.	Hazard Index		Activity Concentration Index (I_{γ})	Observed dose (ERD)	
		External (H_{ex}≤1)	Internal (H_{in}≤1)		D_{out} (nGy/h)	D_{in} (nGy/h)
1	S1	0.023	0.024	0.068	4.278	8.102
2	S2	0.026	0.031	0.076	4.839	9.221
3	S3	0.029	0.031	0.083	5.192	9.616
4	S4	0.015	0.019	0.042	2.651	4.977
5	S5	0.031	0.039	0.089	5.701	10.940
6	S6	0.033	0.043	0.097	6.212	12.002
7	S7	0.034	0.043	0.095	6.067	11.488
8	S8	0.022	0.023	0.059	3.701	6.759
9	S9	0.077	0.099	0.218	13.966	26.817
10	S10	0.024	0.029	0.069	4.407	8.412
Min.		0.015	0.019	0.042	2.651	4.977
Max.		0.077	0.099	0.218	13.966	26.817
A.±S.D.		0.031±0.18	0.376±0.61	0.851±0.92	5.263±2.29	9.995±3.1
P. L.		1	1	6	59	84

Table (4) Results H_{ex}, H_{in}, I_{γ}, D_{out}, and D_{in} of soil samples taken from the surface(5-25)cm

No.	S. C.	Hazard Index		Activity Concentration Index (I_{γ})	Observed dose (ERD)	
		External ($H_{ex}\leq1$)	Internal ($H_{in}\leq1$)		D_{out} (nGy/h)	D_{in} (nGy/h)
1	S1	0.044	0.051	0.124	7.861	14.73
2	S2	0.027	0.030	0.079	4.953	9.341
3	S3	0.021	0.023	0.062	3.914	7.345
4	S4	0.031	0.037	0.089	5.613	10.590
5	S5	0.035	0.038	0.099	6.241	11.668
6	S6	0.042	0.045	0.119	7.443	13.863
7	S7	0.040	0.045	0.107	6.759	12.376
8	S8	0.033	0.037	0.089	5.664	10.550
9	S9	0.056	0.075	0.159	10.218	19.631
10	S10	0.022	0.024	0.064	4.049	7.669
Min.		0.021	0.023	0.062	3.914	7.345
Max.		0.056	0.075	0.159	10.218	19.631
A. ±S.D.		0.035±0.19	0.041±0.20	0.095±0.30	5.869±2.42	11.012±3.3
P. L.		**1**	**1**	**6**	**59**	**89**

The results show that the values of the outdoor effective dose $E_{(out)}$ for samples vary between(0.003;S3 to0.017;S9)mSv/y, and the values of the indoor effective dose rate $E_{(in)}$ for samples vary between(4.977;S3 to 26.817;S9)mSv/y as shown in table (5).While the results of table (6) were from the effective outdoor dose $E_{(out)}$ of the samples vary between (0.005; S3 to 0.013; S9)mSv/y, and the values of the indoor effective dose rate $E_{(in)}$ for samples vary between (0.036;S3 to 0.096;S9)mSv/y. Therefore, the results of the two tables fall within the permissible limit [18].

The (ELCR) for outdoor exposure, given in table (5), ranged from ($0.011*10^{-3}$; S4 to $0.057*10^{-3}$; S9) with an average value of (0.023 ± 0.15) $*10^{-3}$. For indoor exposure it is from ($0.081*10^{-3}$; S4 to $0.434*10^{-3}$; S9)with an average of (0.175 ± 0.42) $*10^{-3}$. The total (ELCR) ranges from ($0.091*10^{-3}$; S4 to $0.491*10^{-3}$; S9)with an average value of (0.199 ± 0.45) $*10^{-3}$. While the (ELCR) for outdoor exposure, given in table (6), ranged from ($0.016*10^{-3}$; S3 to $0.041*10^{-3}$; S9) with an average value of (0.025 ± 0.16) $*10^{-3}$. For indoor exposure it is from ($0.119*10^{-3}$; S3 to $0.318*10^{-3}$; S9)with an average of (0.191 ± 0.44)$*10^{-3}$. The total (ELCR) ranges from ($0.135*10^{-3}$; S3 to $0.359*10^{-3}$; S9)with an average value of (0.216 ± 0.46)$*10^{-3}$. Therefore, the results of these tables fall within the limit recommended by the United Nations Commission on the Effects of Atomic Radiation. The profile $ELCR_{(total)}$ in samples is shown in Fig.(3) [18] .

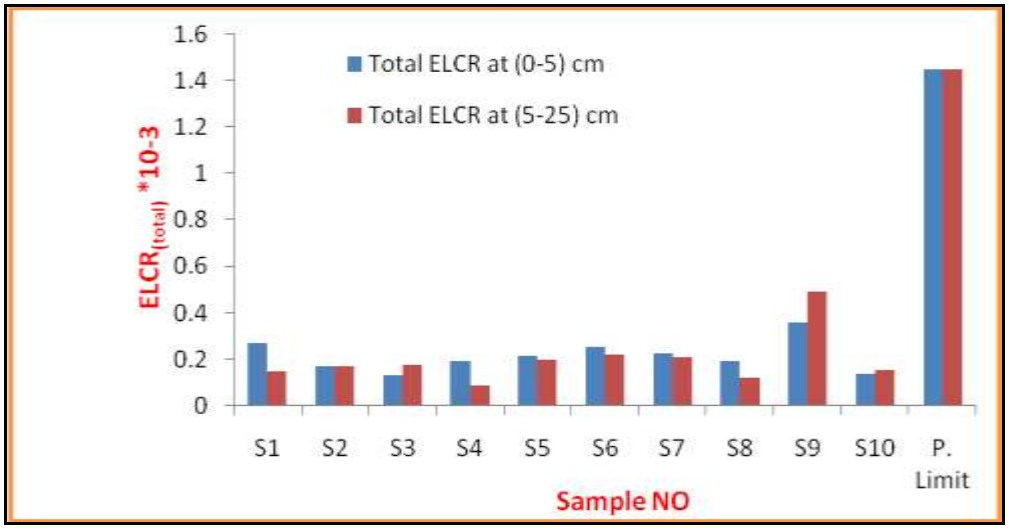
Table (5) Results $AEDE_{(indoor)}$, $AEDE_{(outdoor)}$, $ELCR_{(out)}$, $ELCR_{(in)}$and $ELCR_{(total)}$ in soil samples from the surface (0-5) cm

No.	S.C	$AEDE_{(out)}$(mSv/y)	$AEDE_{(in)}$ (mSv/y)	$ELCR_{(out)}*10^{-3}$	$ELCR_{(in)}*10^{-3}$	$ELCR_{(T)}*10^{-3}$
1	S1	0.005	8.102	0.017	0.131	0.149
2	S2	0.006	9.221	0.019	0.149	0.169
3	S3	0.006	9.616	0.021	0.156	0.177
4	S4	0.003	4.977	0.011	0.081	0.091
5	S5	0.007	10.940	0.023	0.177	0.201
6	S6	0.008	12.002	0.025	0.194	0.219
7	S7	0.007	11.488	0.025	0.186	0.211
8	S8	0.005	6.759	0.015	0.109	0.124
9	S9	0.017	26.817	0.057	0.434	0.491

10	S10	0.005	8.412	0.018	0.136	0.154
Min.		0.003	4.977	0.011	0.081	0.091
Max.		0.017	26.817	0.057	0.434	0.491
A. ±S.D.		0.008±0.09	9.995±3.16	0.023±0.15	0.175±0.42	0.199±0.45
P. L.		0.07	0.4	0.3	1.2	1.45

Table (6) Results $AEDE_{(indoor)}$, $AEDE_{(outdoor)}$, $ELCR_{(out)}$, $ELCR_{(in)}$and $ELCR_{(total)}$ in soil samples from the surface (5-25) cm

No.	S.C	$AEDE_{(out)}$(m Sv/y)	$AEDE_{(in)}$ (mSv/y)	$ELCR_{(out)}*10^{-3}$	$ELCR_{(in)}*10^{-3}$	$ELCR_{(T)}*10^{-3}$
1	S1	0.009	0.072	0.032	0.239	0.270
2	S2	0.006	0.046	0.020	0.151	0.171
3	S3	0.005	0.036	0.016	0.119	0.135
4	S4	0.007	0.052	0.023	0.171	0.194
5	S5	0.008	0.057	0.025	0.189	0.214
6	S6	0.009	0.068	0.030	0.224	0.255
7	S7	0.008	0.061	0.027	0.200	0.228
8	S8	0.007	0.052	0.023	0.171	0.194
9	S9	0.013	0.096	0.041	0.318	0.359
10	S10	0.005	0.038	0.016	0.124	0.141
Min.		0.005	0.036	0.016	0.119	0.135
Max.		0.013	0.096	0.041	0.318	0.359
A. ±S.D.		0.007±0.08	0.058±0.24	0.025±0.16	0.191±0.44	0.216±0.46
P. L.		0.07	0.4	0.3	1.2	1.45



Figure(3): Total risk of lifetime cancer (ELCR) for values of depth (0-5)cm and depth (5-25)cm

5.2. Radon in soil

An average value of Radon concentration was calculated for each location point in Bqm^{-3}.In table (7) and figure (4) we show results of concentration of radon and thoron for all samples at a depth of (50) cm, range from (118.5 ± 10.89;S5 to 1470 ± 38.34; S8) $Bqm^{-3}$with an average value of612.2 ± 23.007Bqm^{-3}, while there was no detection of thoron concentrations in these samples except at sites (S2 ,S3 ,and S7 samples) with a rate of change between (15± 3.87; S2 and S3 to 1470 ± 38.34; S7) Bqm^{-3} with an average value 8 ± 1.481 Bqm^{-3}.In table (8) and figure (5) we show results of concentration of radon and thoron for all samples at a depth of (100)

cm,, range from (92.025 ± 9.59; S8 to 304.45 ± 17.45; S2) $Bqm^{-3}$with an average value of150.743 ± 12.78Bqm^{-3}, while there was no detection of thoron concentrations in these samples except at sites (S1, S2, S3, S5, and S7 samples) all of which possessed the same results with an average value 8.623 ± 2.94Bqm^{-3}

Table (7) Radon(Rn^{222}) and thoron (Rn^{220}) concentration in soil gas at depth (50cm) in Abo Griq district.

N.	S. C.	Radon Concentration ($Bq.m^{-3}$)				Mean of radon concentration ($Bq.m^{-3}$)	Mean of thoron concentration ($Bq.m^{-3}$)
		1	2	3	4		
1	S1	237	541	406	406	397.5 ± 19.94	.....
2	S2	135	237	135	372	219.75 ± 14.83	15± 3.87
3	S3	203	406	507	271	346.75 ± 18.62	15 ± 3.87
4	S4	102	237	304	338	245.25 ± 15.66	.....
5	S5	102	135	135	102	118.5 ± 10.89	.....
6	S6	440	474	643	237	448.5 ± 21.18	.....
7	S7	338	1390	1860	1790	1344.5 ± 36.67	50 ± 7.07
8	S8	1220	1620	1790	1250	1470 ± 38.34	.....
9	S9	1390	981	879	1150	1100 ± 33.17	.....
10	S10	237	575	541	372	431.25 ± 20.77	.....
Average						612.2 ± 23.007	8 ± 1.481

Table (8) Radon(Rn^{222}) and thoron (Rn^{220}) concentration in soil gas at depth (100cm) in Abo Griq district.

N.	S. C.	Radon Concentration ($Bq.m^{-3}$)				Mean of radon concentration ($Bq.m^{-3}$)	Mean of thoron concentration ($Bq.m^{-3}$)
		1	2	3	4		
1	S1	338	203	306	134	245.25 ± 15.66	15± 3.87
2	S2	33.8	541	271	372	304.45 ± 17.45	15± 3.87
3	S3	33.8	135	372	338	219.7 ± 14.82	15 ± 3.87
4	S4	338	237	304	271	287.5 ± 16.96	.....
5	S5	67.6	271	271	169	194.65 ± 13.95	15± 3.87
6	S6	0.00	237	135	203	143.75 ± 11.99	.....
7	S7	304	169	271	237	245.25 ± 15.66	15± 3.87
8	S8	66.9	66.9	167	67.3	92.025 ± 9.59	.....
9	S9	100	268	167	134	150.58 ± 12.27	.....
10	S10	67.3	33.5	100	101	75.45 ± 8.69	.....
Average						150.743 ± 12.78	8.623 ± 2.94

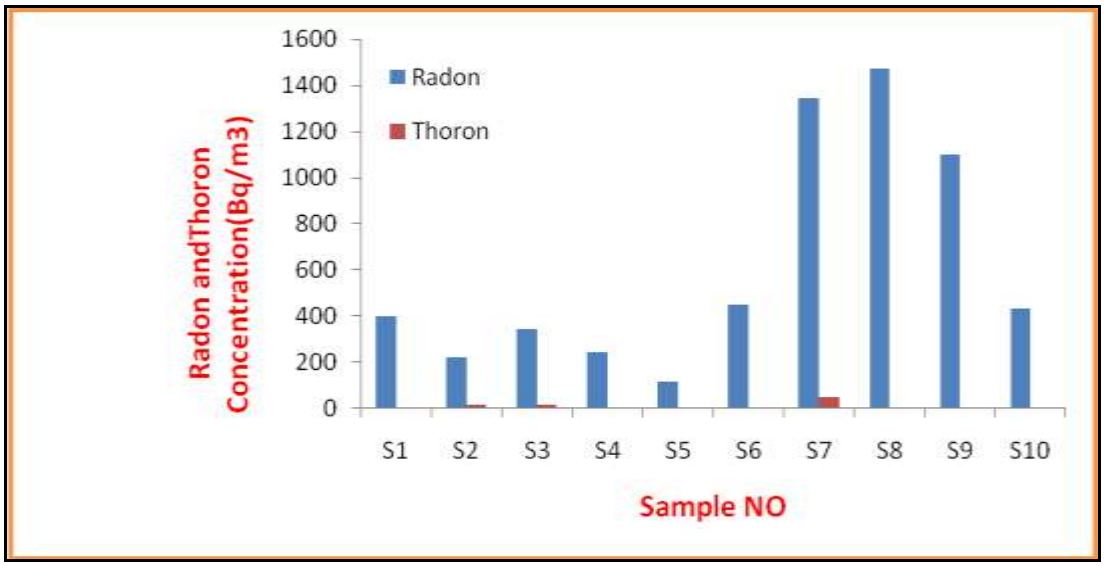


Fig.(4): Radon and Thoron concentration of soil at depth (50) cm

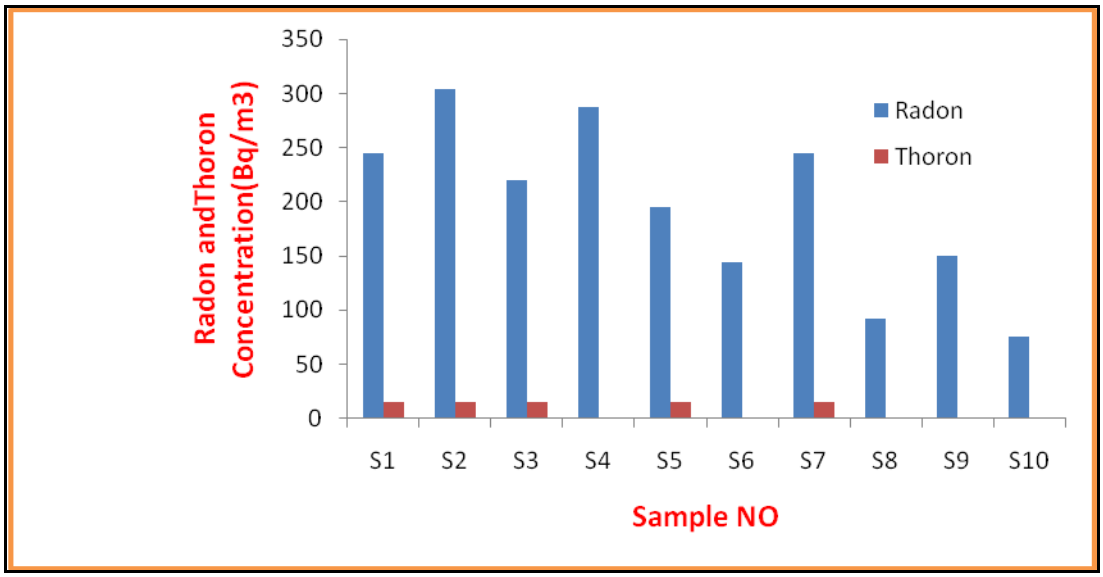


Fig.(5): Radon and thoron concentration of soil at depth (100) cm

6. Conclusion

1. The total concentrations of radioactivity ^{40}k in Hilla soil were lower than the reported global average values. While the concentration of ^{40}k is higher than the rest of radionuclides because these regions often use agricultural and chemical fertilizers frequently.
2. We observe different concentrations of radioactivity (radionuclides) in soil samples within the study area due to the geological differences of these soils.
3. The lifetime risk factor for cancer is less than the global average.
4. Radon levels are low and gradual in all samples of the study area, which are at normal levels compared with local studies. In summary, all studies in Abo Griq district are radiology safe; none of them exceeds the recommended action level.

References:

1. K. H. Lieser "Nuclear and Radiochemistry", Wiley-VchVerlag GmbH, D-69469 Weinheim (Federal Republic of Germany).2nd edition, pp. 29-31; (2001).

2. F.H. Al Marzooqi"Determination of natural radioactivity levels using high-resolution gamma-ray spectrometry", M. Sc. Thesis, University of Surrey, United Kingdom;(2009).
3. M. A. Jaffer"Measurement of natural radioactivity levels around uranium mine in Al-Najaf Al-Ashraf government", M. Sc. Thesis, University of Kufa, Iraq;(2013).
4. M. Bolca, M.M. Sac, B. Cokuysal, T. Karali, and E. Ekdal "Radioactivity in soils and various foodstuffs from the Gediz River Basin of Turkey".Radiation Measurements, Vol.42, No.2, p. 263; (2007).
5. T. Nasir, H. Al Sulaiti, and P. Henry"Assessment of radioactivity in some soil samples of Qatar by Gamma-ray spectroscopy and the derived dose rats", Pak. J. Sci. Res. Ser. A: Phy. Sci. Vol. 55, No. 38,pp. 128-134; (2012).
6. H. Al-Sultaiti, T. Nasir, K. S. Al Mugren, and N. Alkhomashi "Determination of the Natural Radioactivity Levels in North of Dukhan, Qatar Using High-Resolution Gamma-Ray Spectroscopy". Applied Radiation and Isotopes ,Vol.70, pp. 1344-1350; (2012).
7. A. Sroora, S.M. El-Bahia, F. Ahmed, and A. S. Abdel-Haleem"Natural radioactivity and radon exhalation rate of soil in southern Egypt", Appl. Radiat.Isotopes, Vol. 55, pp. 873–879; (2001).
8. H. N. Majeed, A. K. Hasan, and H. J. Hamad "Measurement Natural Radioactivity in Soil Samples from Important Historical Locals in AlnajafAlashraf City, Iraq", Journal of Advances in Chemistry, Vol. 8, No. 1, pp.1472-1478; (2014).
9. S. M. El-Bahi, A. Sroor, G. Y. Mohamed, and N. S. El-Gendy " Radiological Impact of Natural Radioactivity in Egyptian Phosphate Rocks, Phosphogypsum and Phosphate Fertilizers", Applied Radiation and Isotopes, Vol. 123, pp. 121-127; (2017).
10. Cottingh and Greenwood, introduction to Nuclear physics,second edition, University of Cambridge, United kingdom; (2001).
11. E. Podgorsak "Radiation Physics for Medical Physicist", Springer Berlin Heidelberg,New York, USA; (2005).
12. M. Annunziata "Hand Book of radioactivity Analysis", USA, Elsevier Science; (2003).
13. K. H. Hatif and M.K. Muttaleb "Natural Radioactivity level and the measurement of soil gas Radon ,Thoron concentrations in Hilla city", Journal of Kerbala University , Vol. 13, No.1, pp. 103-114; (2015).
14. M. Nejatolahi, F. Mehrjo, A. Sheykhi and F. V. Alamdarlo "Measurement of Indoor Radon Concentration Levels and Effective Dose Assessment in the Zanjan City, Iran"Journal of Environment Pollution and Human Health, Vol. 3, No. 1, pp.1-3; (2015).
15. P.K.Manigandan, and K.K.Natrajan "Activity Concentrations of Natural Radionuclides in Soilsof Rainforest Sites in Western Ghats" International Journal of Students Research in Technology& Management Vol. 2,No.3, pp.103-108; (2014).
16. N.Kaur, A. Singh, M. Kaur, and A. S. Dhaliwal "Measurements of Radon Gas Concentration in Soil", International Journal of Computer Applications (0975 – 8887), International Conference on Advancements in Engineering and Technology , pp. 19-21; (2015).
17. UNSCEAR, United Nations Scientific Committee on the Effect of Atomic Radiation, "Sources and Effects of Ionizing Radiation", Report to General Assembly with Scientific Annexes, Vol. 1: Sources, United Nations, New York; (2000).
18. UNSCEAR,United Nations Scientific Committee on the Effects of Atomic Radiation,"Sources and effects of ionizing radiation",Report to the General Assembly with Scientific Annexes C, D, and E, Vol. 2: Sources, United Nations, New York; (2008).

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